GRADUATE STUDY AND RESEARCH IN CIVIL AND SANITARY ENGINEERING

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IN CIVIL AND SANITARY ENGINEERING

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General Comments

This pamphlet has been prepared especially for students considering graduate study in Civil Engineering and Sanitary Engineering. More complete information may be found in the catalog of the Graduate College which will be sent on requests addressed to that college. Any regulations and requirements included in the Graduate College catalog but not in this pamphlet apply to all graduate students including those in Civil Engineering and Sanitary Engineering.

The Department of Civil Engineering offers advanced study and professional training in the general fields of highway engineering, hydraulic engineering, railway engineering, sanitary engineering, soil mechanics and foundations, structural engineering, geodetic and photogrammetric engineering, and traffic engineering. Facilities for research are available in all these fields and active research programs directed by members of the staff are under way. In programs of graduate study emphasis is placed on both course work and research.

The degrees of Master of Science and Doctor of Philosophy may be attained by qualified students who satisfy the requirements of the department and the Graduate College. Progress toward an advanced degree is measured not only by the accumulation of units of credit in formal course work but also by evidence of intellectual growth and achievement.

The main purpose of graduate study is to enable a student to broaden his knowledge of and increase his competence in a given field. Graduate study, especially in the second and third years of the doctorate, aims at the development of independent scholarship, originality, and competence in research.

The graduate enrollment in Civil Engineering is about 160 students from all parts of the world. Because of this enrollment, it is possible to offer a wide range of courses on all phases of Civil and Sanitary Engineering. Also, the many foreign students bring to the department a variety of experience which broadens the outlook of all who are included in the graduate group.

The extensive research program involving an annual expenditure of approximately seven hundred thousand dollars creates an atmosphere of research and enables students to participate in and come in contact with active research projects. Research is supported by the University as a part of its educational program for undergraduate and graduate students. However, a large part of the research program is supported by special grants from various sponsors including federal and state agencies, technical societies, professional associations, and research councils. Some of the present sponsors are as follows:

American Association of Soap and Glycerine Manufacturers

American Iron and Steel Institute, Welding Research Council

Association of American Railroads

Atomic Energy Commission

Automotive Safety Foundation

Chicago Bridge and Iron Company

Copper and Brass Research Association

Creole Petroleum Corporation

Department of Air Force, Directorate of Intelligence, Air Materiel Command

Department of the Army, Office of Chief of Engineers, Ohio River Division Laboratories

Department of Commerce, Bureau of Public Roads

Department of the Navy, Office of Naval Research, Bureau of Ships

Engineering Foundation

Engineering Research and Development Laboratories of Fort Belvoir, Virginia

Illinois Division of Highways

National Institute of Health

Public Building Service

Reinforced Concrete Research Council

Research Council on Riveted and Bolted Structural Joints

Many of the important developments in engineering are based on the research work which has been done in the laboratories of this department.

Because of the courses in structural engineering and soil mechanics and foundations which are regularly offered during the summer session, it is possible for members of the staffs of other universities to fulfill the requirements for the master's degree in four summers or to make progress toward the doctor's degree.

Importance of Graduate Study

The increasing complexity of many phases of engineering and recent scientific and industrial developments have created a strong demand for civil and sanitary engineers with training beyond that included in undergraduate programs of study. Fields of work for which graduate study is desirable and for which it prepares the engineer are as follows:

1. Advanced analysis, design, consulting, and administration in various specialized fields.
2. Teaching of both fundamental civil engineering courses and advanced work in civil engineering or related fields.
3. Research and development in industrial laboratories or at educational and scientific institutions and government organizations.

Formal graduate course work and participation in creative research enables the civil engineer with graduate training to go beyond the limitations of present practices and to contribute to the progess of his profession.

Admission

Applications for admission are processed by the Dean of Admissions. Application forms can be obtained from the Graduate College, the Office of Admissions and Records, or the Civil Engineering Department. A qualified applicant can be admitted at any time, but in order to avoid delays, a prospective student is urged to submit his application several weeks in advance of the opening of the session in which he plans to enroll. An official transcript from each undergraduate college attended must be sent to the Dean of Admissions. Transcripts of students who enter the Graduate College can not be returned.

The general requirements governing admission are as follows:

Admission to the Graduate College with full status in Civil or Sanitary Engineering is granted to graduates of institutions whose requirements for the bachelor's degree are substantially equivalent to those of the University of Illinois, provided the applicant's preparation is appropriate to advanced study in his chosen major field and his scholastic average is at least 3.75. This average is computed on the basis of the last sixty semester hours of credit recorded (hours may be greater than sixty if the sixtieth hour falls in the middle of the term). Applicants with a grade-point average of less than 4.0, or applicants from schools with different grading systems, should have their application accompanied by at least two letters of recommendation regarding their ability. In converting to a numerical grade, the following equivalents are used: A = 5; B = 4; C = 3; D (the minimum passing grade) = 2.

Admission to graduate courses may be granted only to those who have had the requisite undergraduate work in those courses. Students whose preparation is considered inadequate may be required to take without credit certain undergraduate courses.

Upon the recommendation of the head of the department and with the approval of the Dean of the Graduate College, admission with advanced standing is granted to applicants who have completed a master's degree or the equivalent elsewhere and who desire to become candidates for the doctor's degree at the University of Illinois. The amount of credit to be accumulated at the University of Illinois before the candidate can be admitted to the preliminary examination can be determined only by the advisers in the major and minor fields after the student has registered and completed some work here.

Registration and Program of Studies

Registration. Dates for registration in the Graduate College are shown in the calendar, a copy of which will be sent upon request. Registration for the first semester is the middle of September; that for the second semester, the second week of February; and that for the summer session, the middle of June. A former student who registers late must pay a late registration fee of $5.00. The registration of a new student is accepted at any time, provided he is prepared to enter courses already under way for credit reduced in proportion to the length of time which has elapsed since instruction began. He is not charged the late registration fee.

A graduate student obtains a program card and other registration material from the Graduate College office during scheduled registration days or at any time thereafter. The student should then consult his departmental adviser as explained below. The adviser suggests the course of study and, in the case of a new student, determines what deficiencies, if any, must be made up; these are listed on a prerequisite blank. If there are no deficiencies, the adviser so indicates on this form. When the program card has been approved by the adviser, the student secures on it the signatures of the individual instructors in whose courses he is enrolled. The program of a student who has a staff appointment or who holds a University Fellowship must be approved by the Dean of the Graduate College before his registration is completed. This signature can be obtained on the first day of registration or at any time thereafter, but not before. Program cards of other students do not require the Dean's signature.

Advisers. Every graduate student must have an adviser who assists in planning and carrying through a program of graduate work which fits the needs and wishes of the student. New graduate students are interviewed by the head of the department who assigns an adviser in the student's major field of interest. The adviser for research assistants is normally the staff member in charge of the assistant's research program.

Unit Credit for Courses. Courses offering graduate credit are numbered from 300 to 399 when they are open to advanced undergraduates and to graduate students, and are numbered 400 and above when they are open to graduate students only.

Graduate credit is measured in terms of units. One unit is considered the equivalent of four semester hours. The normal program for a full-time graduate student is four units each semester; the maximum permissible is five. The credit which may be earned in individual courses is indicated in the course listing and is in some instances variable. The credit for which the student is actually registered in every specific course is entered on the student's program card by his adviser and is subject to the approval of the Dean of the Graduate College.

Miscellaneous Courses. A graduate student carrying a normal graduate program may elect one miscellaneous subject (a course which does not give credit toward an advanced degree). If it is necessary for a graduate student to carry at the same time more than one miscellaneous subject, he may not register for a full graduate program. Courses intended to give graduate students a reading knowledge of French or German are regarded as miscellaneous courses. A student who elects a miscellaneous course is required to register in it and do the assigned work.

Auditing Privileges. A graduate student is permitted to attend classes as an auditor, provided a card bearing the approval of his adviser and of the instructor is filed at the Graduate College office. A student should not enter on his program card courses which he plans to attend as an auditor.

Graduate Programs for Employed Students. A student who is employed can not expect to complete his academic work as promptly as he otherwise could. The academic work carried by assistants and others on the University staff is limited by statute. Those employed outside the University are expected to reduce their programs of work in accordance with these regulations. The maximum amount of academic work is determined by the terms of employment as follows:

	Maximum Registration	
Nature of Appointment	*Semester*	*Summer Session*
Full time	1 unit	1 unit
Three-fourths time	2 units	1 unit
Two-thirds time	2¼ units	1 unit
Half time	3 units	1½ units
One-third time	3½ units	2 units
One-fourth time	4 units	2 units

Under special circumstances additional thesis or research credit may be obtained.

Time Limit for Advanced Degrees. From the time of entrance upon graduate study at the University of Illinois, the work for a master's degree must be completed in not more than six calendar years, and that for a doctor's degree in not more than seven calendar years.

Graduate Study in the Summer. During the summer session, a student may take courses for credit toward higher degrees, subject to the residence requirements listed below. The normal program for a summer term is two units; two and one-half units may be carried with the approval of the adviser. In no case will a student be permitted to carry more than two and one-half units.

A limited number of Civil Engineering graduate courses are offered during the summer session. The fields included are structures and soil mechanics and foundations. The courses offered vary from summer to summer, so that by careful planning, it is possible to complete the requirements

for a master's degree by summer study and make progress toward the doctor's degree.

Students from Abroad. A foreign student who wishes to be admitted to graduate work at the University of Illinois should write to the Dean of Admissions, enclosing copies of his academic records certified by the educational institutions previously attended. Immigration requirements demand that a foreign student admitted to this country as a non-quota student must register each semester for not less than three units of work if he is enrolled in the Graduate College.

The Assistant Dean for Foreign Students assists foreign students with problems involving passports, visas, and other matters.

A foreign student whose native tongue is not English is required to take an examination in English before registration. If his command of the language is not adequate, he is required to enroll in courses for the study of English as a foreign language, but credit earned is not applicable to an advanced degree. In this case the student can not carry a full program of academic work and it will take relatively longer to complete the requirements for the degree desired.

Grades. Grades are recorded by the following letters: A, B, C, D, E. Any student who receives two units of a grade below B must complete two additional units of A or B grade to qualify for an advanced degree. Three units of a grade below B disqualify a student as a candidate. A grade of E in any course in the major field precludes the conferring of a degree in the academic year in which the failure is incurred.

Petitions. The normal procedures and requirements of the Graduate College are indicated in this pamphlet, but these may be modified occasionally for justifiable reasons. A student may petition the Dean and the Executive Faculty of the Graduate College for exceptions, but he should do so only after consultation with his adviser. Forms can be secured at the Graduate College office.

Residence. A student is in residence only when registered in the Graduate College and spending full time on the Urbana campus. Such a student earns one semester of residence if he is registered for two or more units. Students in residence who are carrying lighter programs of work must spend a proportionately longer time in satisfying this requirement; thus, for example, a full-time assistant registered for one unit each semester would discharge the residence requirement in four semesters of work. A student who is employed outside the Champaign-Urbana community is not considered to be in residence even though he is registered in a campus course.

The Degree of Master of Science

The degree of Master of Science is offered in the fields of Civil Engineering and Sanitary Engineering.

Credit Requirements. A candidate for the master's degree must complete at least eight units of graduate work with satisfactory grades. A thesis, with from two to three units of credit, is normally a part of the eight units, but may be waived, as explained under the paragraph on master's thesis below. When the thesis requirement is waived, the candidate must present at least nine units of course work.

Residence Requirements. A candidate for the master's degree is required to be in residence for the equivalent of at least two semesters. Attendance during four summer sessions in each of which the student is registered for not less than one unit of work, or in one semester with not less than two units and two summer sessions with not less than one unit each, is regarded as the equivalent of two semesters in residence. Registration for more than two units in a regular semester, or for more than one unit in a summer session, does not shorten the time which must be spent to discharge the residence requirement.

Work Done Elsewhere. A graduate student who has done graduate work in other approved institutions may petition to obtain credit, not to exceed four units, toward the master's degree by passing examinations in that work. Admission to such examinations requires the prior approval of the Dean of the Graduate College. The acceptance of credit for work completed elsewhere does not reduce the residence requirement of two semesters.

If it is recommended in advance by the adviser, the Graduate College may permit a student to register for work at a laboratory elsewhere offering facilities not available at Urbana, or in approved field work, with the understanding that such work will be accepted for graduate credit if completed satisfactorily. The adviser examines the student's transcript and examines the student directly when he returns to this campus and then makes a final recommendation to the Dean of the Graduate College concerning the credit to be given.

Majors and Minors. A candidate for a master's degree may do all his work in one field, or he may select a major and one minor, or a major and two minors, as indicated in specific cases in the latter part of this pamphlet. A major or minor denotes the field of knowledge of a department, or such part thereof as constitutes a separate and independent division of that field. For a master's degree a major comprises work totaling a minimum of four units. Less than one unit of work does not satisfy the requirements for a minor.

Thesis. The subject of a thesis for the master's degree must be filed at the Graduate College office *by the student during the registration period prior to his graduation.* A student usually devotes two units of work to his thesis, and no more than three units of thesis credit may be included in an eight-unit program except by special permission. For specific instructions with reference to the preparation and form of the thesis, the student should obtain at the Graduate College office a copy of the leaflet "Instructions for Preparation of Theses." Two copies of the thesis with Certificate of Approval must be presented to the Graduate College office by the date specified in the calendar of the Graduate College. Candidates are expected to have at least four copies of the thesis. The original and first carbon must be deposited in the Graduate College; the other two are for the major department and the author. The Certificate of Approval for the master's thesis must be signed by the person under whose immediate supervision the thesis was prepared and also by the head of the major department. Blank certificate forms can be obtained at the Graduate College office.

The requirement of a thesis may be waived, on the recommendation of the department and with the approval of the Dean, *provided application to waive the thesis is made at the time for announcing thesis subjects.* A student excused from writing a thesis must replace it with courses of instruction. In this case, credit in research or thesis is not accepted in partial fulfillment of the requirements for the master's degree.

Thesis Work on Leave of Absence. A student who has completed six units of course work in residence and who wishes to complete the thesis in absentia should consult first with his adviser. If the request meets with the latter's approval, a petition is submitted. The petition must include an outline of the proposed investigation and evidence that adequate facilities for pursuing it are available. If the work is to be done in an industrial laboratory, it is necessary to secure a letter from the company releasing to the University all patent and publication rights.

Suggested Programs. Suggested programs in the various fields in Civil and Sanitary Engineering are presented on page 35.

Conferring of Degrees. The master's degree is conferred in February, June, August, and October. Each student is responsible for entering on his registration cards, during the registration period preceding the time at which he expects to be awarded his degree, the fact that he is a candidate for a degree to be awarded at the end of that semester. If the candidate is not currently registered in the Graduate College, he must present his application to receive a degree at the Graduate College office no later than the final date specified by that college.

Not later than one week before the degree is conferred, each candidate for an advanced degree must obtain a clearance paper from the Graduate

College. The student must obtain all the signatures called for on the form and return it to the Graduate College.

The Degree of Doctor of Philosophy

The degree of Doctor of Philosophy is offered in the fields of Civil Engineering and Sanitary Engineering.

Residence Requirements. For the degree of Doctor of Philosophy, the student must spend three "years" in resident study at an accredited educational institution; such "years" are defined as follows:

First "Year." The time required to complete eight units of graduate work with satisfactory grades.

Second "Year." The time required to progress from the completion of the first year's work through the completion of the preliminary examination. This involves obtaining satisfactory grades in eight more units of graduate work, completion of the foreign language requirement, and passing the preliminary examination.

Third "Year." The time spent between passing the preliminary examination and the completion of all requirements for the doctor's degree, including eight units of research, writing a satisfactory thesis, and passing the final examination.

A student who spends the first two years in residence at the University of Illinois may petition to spend the last year in absentia. A student who has completed the first year of graduate work elsewhere must be in residence during the two remaining years. In exceptional cases, a student with two years of graduate study elsewhere who satisfies his major department that he has completed work equivalent to the standard departmental requirements is permitted to take his preliminary examination, provided he has fulfilled the language requirements. If such a student passes the preliminary examination, he may complete the requirements for the Doctor of Philosophy degree by devoting the third year to research in residence.

A student may satisfy the residence requirement in part by attending summer sessions at the University of Illinois. Attendance during four summer sessions is considered the equivalent of one year's residence. However, at some time during the second or third years of his doctoral program, the student must be in residence at the University through two successive semesters.

Majors and Minors. A candidate for the degree of Doctor of Philosophy is required to pursue a major subject in the area of his research interest. He also is required to choose one or two minor subjects. If only one minor is chosen, it is called a "sole minor," and must be taken in an area other than that of the major. Credit for it must be earned by work representing

not less than four units. If two minors are chosen, the first may be a subject closely related to the major. With the approval of the adviser, it may be a division of the major field of study; it must involve at least two units. In such a case, the second minor (not less than two units) must be taken in an area other than that of the major.

Language Requirements. The student is required to demonstrate his ability to read two of the following languages: French, German, or Russian. He should take his language examinations as early as possible and must pass both not later than two months prior to the preliminary examination, or during the semester (or summer session) preceding that in which he is admitted to the preliminary examination. The dates of the language examinations and the latest dates when application for admission to these examinations may be made are shown in the University calendar (see Graduate College catalog). Alternatively, a student is certified in either language if he obtains a grade of B or better in French or German 401. Certification of proficiency in foreign languages is not accepted from other colleges or universities. The examinations must be taken at the University of Illinois.

Doctoral Committee. A permanent doctoral committee for each student is appointed by the Dean of the Graduate College upon recommendation of the executive officer of the department in which the student is doing his major work. The committee conducts the preliminary and the final examinations.

Preliminary Examinations. A candidate for the doctor's degree must pass a preliminary examination intended to test his knowledge of his major and minor fields of study. He is not admitted to the examination before (1) he has passed the two required language examinations or their equivalent, (2) he has satisfactorily completed at least sixteen units of graduate work, and (3) his adviser and the head of the department of his minor field of study consider that he has adequate preparation in his major and minor fields. This examination, conducted by the candidate's doctoral committee, is partly or entirely oral.

Final Examinations. When the thesis has been completed, if the major adviser so recommends, the candidate is given his final examination by his doctoral committee. A student in the third year of study who fails to meet the expectations of the professors in charge of his work, or in any way fails to maintain the standard of scholarship and power of research expected of him, may be refused admission to the final examination.

The final examination must be completed at least two weeks before the degree is conferred. This examination is concerned primarily with the research work of the student as embodied in his thesis, but it may be much broader and extended over the whole field of study of the candidate. The

intention of the final examination is to determine that the candidate has a satisfactory grasp of his major subject as a whole, and a general acquaintance with the fields of knowledge represented by his course of study.

The final examination is oral and is conducted entirely in the presence of the doctoral committee.

Thesis. The Doctor of Philosophy is primarily a research degree; consequently, the candidate is required to demonstrate his capacity for independent research by the production of an original thesis on some topic connected with his major field of study. The subject of the thesis should be chosen by the end of the second year and must be reported to the doctoral committee and the Graduate College at the time of the preliminary examination. The student should register for credit in research in relation to the amount of time he plans to devote to his dissertation, four units being the equivalent of full-time work.

Not later than two weeks before the time set for his final examination, and not later than four weeks before the time when he hopes to receive the degree, the candidate must submit to the Graduate College, for approval of the format, two typewritten copies of his thesis in final form. Style and form must comply with the regulations given in the leaflet "Instructions for Preparation of Theses," copies of which can be obtained in the Graduate College office. It is expected that each candidate will have at least four copies of the thesis. The original and first carbon must be deposited in the Graduate College; the other two are for the major department and the author. After the thesis has been checked at the Graduate College office, the student must arrange for each member of the doctoral committee to read the thesis before the date of the final examination.

Formal publication of the thesis, either in its entirety or in a condensed form, is not required. However, students should consider the advantages, both to themselves and to their professional fields, of publication of the significant methods and findings of their research. If published, the article or book should have a note indicating that the material is, or is based upon, a dissertation submitted in partial fulfillment of the requirements for the Doctor of Philosophy (or other) degree at the University of Illinois.

In order to insure that theses are available for use by others, it is required that they be microfilmed. Each candidate who passes the final examination must pay a fee of $25.00 and deposit a typewritten abstract of his thesis, of approximately six hundred words, together with the original and first carbon of the complete thesis. This fee provides for (1) microfilming of the complete dissertation, with one copy deposited in the University of Illinois Library, (2) publication of an abstract of six hundred words or less in *Dissertation Abstracts.*

Conferring of Degrees. The doctor's degree is conferred in February,

June, and October. Not later than one week before the degree is to be conferred, each candidate for an advanced degree must obtain a clearance paper from the Graduate College office. The student must obtain all the signatures called for on the form, and then return it to the Graduate College.

Fellowships, Scholarships, and Assistantships

University Fellowships. University Fellowships are awarded each year to promising graduate students for work in any field in which the University offers a master's or doctor's degree. Fellowships carry exemption from tuition and all fees of the regular academic year, except the hospital and medical service fee of $7.00 a semester, during the period of the fellowship. The stipend is $1,200 for the academic year.

The holder of a University Fellowship is granted free tuition for the summer session following the termination of the academic year in which his fellowship was effective, if he desires to continue his studies during the summer. A candidate for a fellowship must be a graduate of the University of Illinois, or of a college or university having equivalent requirements for the bachelor's degree.

Application must be made on blanks obtained from the Dean of the Graduate College and should be submitted before February 15 of the academic year preceding that for which the fellowship is desired.

A person appointed is notified on April 1, and must send the Secretary of the Board of Trustees notice of his acceptance or refusal by April 15. If he accepts, he must agree that the appointment will not be resigned to take a similar one at any other institution during the year for which it is awarded, that he will not engage in any outside employment for remuneration, and that, without the consent of the University, he will neither attempt to hold concurrently any other fellowship carrying a stipend, nor abandon the appointment during the year.

Tuition Scholarships. Beginning in September, 1957, the Graduate College will award, in addition to the University Fellowships, a number of scholarships without stipend but carrying the same tuition and fee exemptions as the University Fellowship. An applicant for a scholarship should fill out and submit the regular fellowship form. Unless the applicant indicates otherwise, he will also be considered for a fellowship. In general, scholarships will be awarded to promising candidates for whom fellowship funds can not be found.

Resident Post-Doctoral Fellowships. A limited number of post-doctoral fellowships carrying a maximum stipend of $3,000 a year are provided. These fellowships are intended to provide opportunities for further training and development for outstanding students of great originality who wish to

make use of the research facilities of the University after receiving the doctor's degree. An applicant must submit a detailed program of research or study which he has conceived and formulated himself and, if possible, be interviewed by the Graduate College Fellowship Committee. Applicants should apply for this fellowship by February 15.

Research Assistantships in the Engineering Experiment Station. The Engineering Experiment Station is devoted to the study of problems of special importance to engineering and to the stimulation and elevation of engineering education. By undertaking a line of graduate study in close association with some one of the projects carried on in the Station, the student comes into contact with aspects of his specialty which he would rarely touch in a purely academic study, and thus broadens his outlook. The Experiment Station makes available apparatus, equipment, and the services of machinists, which materially facilitate the carrying on of investigations.

Research assistantships, with a stipend of $1,700 for an academic year of two semesters, are open to graduates of approved technical colleges and universities. Applicants to whom these assistantships are awarded devote one-half of their time to the work of the Engineering Experiment Station and one-half to graduate studies. Each appointment is made for one academic year and may be renewed for the second year if an assistant's services are satisfactory. At the end of this period, if all requirements have been met, the degree of Master of Science is conferred.

Appointments to research assistantships are made only to students with outstanding records or other excellent qualifications. Appointments are given to first-year and second-year graduate students, but only rarely to third-year students who have not previously studied at Illinois. In general, with a half-time assistantship, two academic years of residence are required in order to obtain the master's degree.

A number of research assistantships in Civil and Sanitary Engineering are available. They include assistantships established by the University, and others provided by cooperative research agreements with state and federal agencies, technical societies, and engineering associations. Fields of research which are now active include steel, concrete, and wood structures, theory and analysis, structural dynamics, structural welding, soil mechanics, foundations, retaining walls, culverts, earth dams, highway pavements, hydraulic engineering, and sanitary engineering. It is usually possible to assign a research assistant to a project in the field of his special interest. Often the research in which he is engaged forms the basis of his thesis, but his thesis is not restricted to this field.

Applications for research assistantships should be made to the Head of the Department of Civil Engineering not later than March 15 to be

considered for appointments effective the following September. Although most appointments are made for the academic year beginning in September, some appointments may also be available in February or June.

Teaching Assistantships. Occasionally there are openings for teaching assistants. The conditions governing these assistantships are essentially the same as those that apply to research assistantships.

Acceptance Agreement. The University of Illinois adheres to the following resolution adopted by the members of the Association of American Universities and a number of other graduate schools of North America:

"In every case in which a graduate assistantship, scholarship, or fellowship for the next academic year is offered to an actual or a prospective graduate student, the student, if he indicates his acceptance before April 15, will still have complete freedom through April 15 to reconsider his acceptance and to accept another fellowship, scholarship, or graduate assistantship. He has committed himself, however, not to resign an appointment after this date unless he is formally released from it."

Fees and Expenses

Students registering for resident work pay fees each semester or summer session according to the following schedules:

SEMESTER FEES

Tuition Fee	*Regular Schedule (Over two units)*	*Reduced Schedule (Two units or less)*
Residents of Illinois	$ 65.00	$20.00 per unit
Nonresidents of Illinois	250.00	80.00 per unit
Laboratory, Library, and Supply Fee	11.00	5.50
Hospital and Medical Service Fee	7.00	7.00
Students who present evidence of participation in any other insurance system providing the same benefits as those covered by the University fee may petition the Dean of Students for refund of this fee. Students registered for one unit or less are exempt from this fee.		
Illini Union Service Charge	7.00	7.00
Students registered for one unit or less are exempt from this fee.		

SUMMER SESSION FEES

Tuition Fee	*Regular Schedule (Over one unit)*	*Reduced Schedule (One unit or less)*
Residents of Illinois	$ 32.50	$20.00 per unit
Nonresidents of Illinois	87.50	48.00 per unit
Effective June, 1958, the tuition fee for nonresidents will be $125.00. For a reduced schedule (one unit or less), the fee will be $80.00 per unit.		

Laboratory, Library, and Supply Fee	5.50	2.75
Hospital and Medical Service Fee Students registered for one-half unit or less are exempt from this fee.	3.50	3.50
Illini Union Service Charge Students registered for one-half unit or less are exempt from this fee.	3.50	3.50

EXEMPTION FROM FEES

Holders of general scholarships are exempt from tuition fees only. University Fellows and all members of the academic and research staffs of the University (including part-time research assistants) may register for courses without payment of the tuition fee, the laboratory, library, and supply fee, and the Illini Union service charge, during the period of their appointment and the summer session following, provided their annual salary is less than the minimum salary for a full-time assistant ($3,400 for a nine-month appointment; $4,150 for a twelve-month appointment). Exempt under the same conditions are permanent employees on the non-academic staff.

SPECIAL FEES	*Regular Schedule (Over one unit)*	*Reduced Schedule (One unit or less)*
Late Registration Fee Former students, whether on appointment or not, who register after the regular registration days in either semester are subject to this fee.	$ 5.00	$ 5.00
Change of Program Fee This fee is charged for every change slip issued after the completion of registration.		1.00
"In Absentia" Students enrolled for thesis work for the master's or doctor's degree on leave of absence pay the regular tuition fee only, as listed above.		
Transcript Fee Each student who has paid all his University fees is entitled to receive, without charge, one transcript of his record. For each additional transcript the fee is $0.50.		0.50

Service Charge for Deferred Fees

A service charge of ten per cent of the amount of fees deferred, but not to exceed $3.00 a semester, is assessed for the privilege of deferring fees. If deferred fees are paid in full within ten days after registration, the service charge is refunded except that a minimum service charge of $1.00 is retained by the University in all cases. The hospital and medical service fee, the Illini Union service charge, the service charge for deferring fees, and all charges from previous semesters must be paid on the day of registration.

Housing

The University does not operate residence halls for graduate students. However, a limited number of one-room efficiency apartments for married students is available in the University-owned Student-Staff Apartment Building. Applications for these units may be obtained from the Housing Division, 108 Illini Hall, or the Graduate College. In addition, the Director of the Housing Division maintains a list of apartments and rooms available in private homes in the community. Arrangements for housing should be made as far in advance as possible.

Buildings and Equipment

The teaching and research activities of the Department of Civil Engineering are conducted in large portions of two major buildings — Civil Engineering Hall and Talbot Laboratory — and completely occupy several smaller buildings, including the Sanitary Engineering Laboratory, the Surveying Building, and the Hydraulic Engineering Laboratory.

Civil Engineering Hall. This building has a floor area of 64,000 square feet. It contains design rooms to provide tables for junior and senior civil and sanitary engineering students, and a similar room for the use of graduate students.

The department office, the student lounge, and the Engineering Library are located in this building.

Talbot Laboratory. The Talbot Laboratory is the outstanding building of its kind in the country. Its floor area of 82,000 square feet is shared by the Department of Civil Engineering and the Department of Theoretical and Applied Mechanics. It houses the following laboratories for testing, research, and instruction. The *structural laboratory* is in the large central crane bay, where testing machines varying in capacity from 30,000 pounds to 3,000,000 pounds are located. The latter machine has a vertical height sufficient to accommodate tension and compression specimens thirty-eight feet long. Large machines for determining the fatigue strength of full-size structural members are important features of this laboratory. The laboratory is served by a traveling crane. Extensive facilities are available for studying the behavior of structures and structural components of wood, steel and other metals, reinforced concrete, and prestressed concrete and for the study of vibrations in structures and their action under impact loads, earthquake motions, or blast forces.

The *concrete laboratory* is equipped for the study of proportioning and mixing concrete and of its physical properties. The *highway materials laboratories* are equipped for tests and research in bituminous and nonbitumi-

nous highway materials. The *soil laboratories* are equipped to perform the various soil tests and provide excellent facilities for research, including a vertical reflecting projector for compilation of maps from aerial photographs and other sources.

A radar speed meter, several automatic traffic recorders, and other traffic study equipment are available for highway traffic research.

Graduate students in civil engineering commonly elect courses which make use of the laboratories of the Department of Theoretical and Applied Mechanics which are also located in this building. The laboratories include the *hydraulics laboratory,* which is equipped with a standpipe, pumps, weirs, orifice tanks, turbines, long concrete channels, and other facilities for instruction and research in hydraulics; the *applied mechanics laboratory,* equipped with standard and special testing machines of various types and capacities; the *fatigue of metals laboratory,* equipped with a variety of machines for testing metals under fatigue loading; the *concrete research laboratory,* which is well equipped with testing machines, mixers, a concrete saw, a core drill, and other tools and equipment used in fabricating and testing members of plain and reinforced concrete and which is supplemented by the large crane bay and its testing machines; and several special laboratories, such as those for railroad rails, plastics, photoelastic investigations, and creep of metals.

Two well-equipped machine shops are provided for use in making and repairing equipment and apparatus for instruction and research.

Sanitary Engineering Laboratory. This building is modern in every respect and well equipped. It has a floor area of 5,000 square feet and provides classrooms, offices, and laboratories for instruction and research in sanitary engineering. Sewage is supplied to apparatus in this building by a connection with the main city outfall sewer adjacent to the building. Research in the purification of water, in the treatment of sewage and of industrial wastes, and in other branches of sanitary engineering requiring hydraulic, chemical, and biological equipment is being carried on in the Sanitary Engineering Laboratory. Opportunities to participate in the established projects and to pursue research independently on selected projects are offered.

Surveying Building. This building is situated on the south campus. It contains drafting rooms, classrooms, offices, and an extensive collection of modern instruments which are used for advanced instruction in geodetic and photogrammetric engineering. For practice in precise control surveying including geodetic astronomy, the following equipment is available: first-order Parkhurst theodolite, first-order Wild N-3 level, Wild T-2 theodolite with prismatic astrolable attachment, Zeiss pendulum level, lovar tapes, precise foot, and yard rods, chronometer, etc. For practice in photogrammetric compilation of maps from aerial photographs the following are

available: stereocomparagraph, contour finder, sketchmasters, slotted templet cutter, reflecting projector, etc.

Hydraulic Engineering Laboratory. The Hydraulic Engineering Laboratory occupies a total usable space in excess of 10,000 square feet. Over 60 per cent of the area is used for the construction and testing of hydraulic models and flow apparatus. The remainder of the area is devoted to offices, shop facilities, and dark room. The main laboratory pumping system is composed of five pumps with a combined capacity of 5,000 gallons per minute at a head of about forty-five feet. Water storage and sump facilities, with a capacity in excess of 22,000 gallons, supply the water recirculation system. Piping arrangements are designed to permit simultaneous constant head and high rate flows without interference.

A separate system for the use of graduate students is maintained in the north laboratory. This test area contains its own pump, water supply, circulation system, and measuring apparatus.

Instrumentation is of the latest types. A unique feature of the laboratory is a heated space 10 feet wide and 330 feet long equipped with a traveling crane for the handling of heavy equipment. This space is well adapted to studies relating to either open channel or pipe flow.

Available within the laboratory are complete shop facilities for the construction of models, including apparatus for molding plastic materials.

Cameras for both still and moving pictures are a part of the regular equipment. A darkroom permits the processing of photographs. Mechanical calculators are available for the analytical interpretation of experimental data.

Library Facilities. The University Library's resources for advanced study and research are outstanding. The present holdings are in excess of three million volumes, with all but about two hundred thousand volumes located in Urbana. More than eighteen thousand periodicals and serials are currently received, extensive back files are maintained, and the Library is a government document and Atomic Energy Commission depository.

The Library's bibliographical facilities comprise a union catalog representing titles owned by about two dozen major American and foreign libraries, printed catalogs of the Library of Congress and several other national libraries, national and trade bibliographies of special subjects, and similar aids.

Outstanding collections have been developed in the science-technology fields. The Engineering, Physics, Mathematics, Chemistry, and Natural History Libraries are conveniently located to the College of Engineering. Graduate students have free access to all library bookstacks. Microreproduction facilities, interlibrary loan service from other institutions for those engaged in research for dissertations, individual reference service,

and assistance in using the collections and the card catalogs are also available.

Computing Machines. Available for civil engineering research are a number of computing machines for use in studies of numerical methods of various kinds and for the solution of problems of stress analysis, instability, vibration, impact, heat flow, etc. Electric desk calculators are located in computing laboratories in Talbot Laboratory, Civil Engineering Hall, and the Structural Research Annexes. Use may be made of the IBM punched card tabulating and computing equipment in the Statistical Service Unit. Use may also be made, under supervision, of the Illiac, the high-speed electronic digital computer which the University has built. This computer is one of the best of its type in the country, having a high-speed memory of 1,024 numbers of forty binary digits (twelve decimal digits) and a magnetic drum memory of 12,800 numbers. When operating with the high-speed memory, the computer can multiply approximately 1,200 pairs of numbers per second. Among the programs available are codes for the solution of sets of simultaneous linear algebraic equations, the integration of linear or nonlinear differential equations, or of a set of differential equations, the evaluation of the roots of high order polynomials, and the determination of the eigenvalues and the eigenvectors of matrices. Using only the high-speed memory, a system of thirty-nine simultaneous linear algebraic equations with thirty-nine unknowns can be solved in less than four minutes. With the magnetic drum memory, it is possible to solve a system of 140 simultaneous equations in approximately two hours. This computer is used extensively in the analytical research programs in civil engineering. It makes possible investigations involving complex computations which would be impracticable or even impossible by other means and greatly expands the scope of analytical research.

Courses in Civil Engineering and Sanitary Engineering

The prerequisite for graduate work in Civil Engineering and Sanitary Engineering is the equivalent of the undergraduate courses required for the degree of Bachelor of Science in the branch of the subject in which registration is desired.

Courses for Graduates

401. Geodetic Engineering. Elements of geodesy; principles and practice of precise triangulation, traverse, and levels. I; 1 unit. Prerequisite: Bachelor of Science degree in civil engineering. SCHMIDT.

402. Geodetic Engineering. Astronomic determination of latitude, longitude, and azimuth; systems of plane coordinates; map projections; electronic and special control surveys. II; 1 unit. Prerequisite: Bachelor of Science degree in civil engineering. SCHMIDT.

420. **Highway Pavement Design, I.** Analysis and methods of measurement of road surface properties related to vehicle performance; factors affecting pavement durability; traffic wear, climate, chemical action, combined effects; composition design of flexible and rigid pavements for proper road surface properties, load carrying capacity, wear resistance, stability and durability. I; 1 unit. Prerequisite: Civil Engineering 220 or equivalent. DANNER.

421. **Highway Pavement Design, II.** Structural design of flexible and rigid pavements; loading characteristics, static, impact and repeated loads; load distribution through pavement layers, factors affecting distribution, methods of analysis; evaluation of subgrade support; criteria for selecting design values. II; 1 unit. Prerequisite: Civil Engineering 420 or consent of instructor. DANNER.

422. **Municipal Administration and Engineering.** Legal authority of municipalities, forms of municipal government; municipal functions, organization, and management; city finance; engineering functions of city government; city planning and zoning, building codes and inspection; street lighting; public utilities; city cleaning; recreational development. II; 1 unit. Prerequisite: Bachelor of Science degree in civil engineering or consent of instructor. DANNER.

423. **Traffic Planning.** Traffic engineering planning functions; urban and rural master traffic plans; traffic analyses for new or existing streets, highways, and terminal facilities. II; 1 unit. Prerequisite: Civil Engineering 323 or equivalent. BAERWALD.

425. **Railroad Location and Operation.** Track and traffic capacity, optimum size of train, train performance diagram, train scheduling and make-up, improvement of existing lines, examples of modern location. I; 1 unit. Prerequisite: Civil Engineering 203, 226, or equivalent experience, or consent of instructor. HAY.

426. **Railroad Location and Operation.** Roadbeds under load, roadbed stabilization, design of ballast section, ties, rails, and fastenings, economies of grade separation, recent examples of roadway and track problems. II; 1 unit. Prerequisite: Civil Engineering 425, or equivalent, or consent of instructor. HAY.

440. **Water Supply.** Water resources and use; design, construction, and operation of water distribution systems. I; 1 unit. Prerequisite: Bachelor of Science degree in sanitary engineering or equivalent. DIETZ.

443. **Sewerage.** Design, construction, maintenance, operation, and financing of sewer systems. II; 1 unit. Prerequisite: Bachelor of Science degree in sanitary engineering or equivalent. DIETZ.

444. **Sewage Disposal, Wastes Disposal, and General Sanitation.** Fundamental principles and practical considerations associated with sewage and industrial waste disposal, including the design, operation, and control of the various treatment units. II; 1 unit. Prerequisite: Bachelor of Science degree in sanitary engineering or equivalent. DIETZ, ENGELBRECHT.

446. **Water Purification and General Sanitation.** Fundamental principles and practical considerations associated with water treatment, including the design, operation, and control of the various unit processes. I; 1 unit. Prerequisite: Bachelor of Science degree in sanitary engineering or equivalent. DIETZ.

448. **Sanitary Engineering Laboratory.** Laboratory evaluation of the various unit processes practiced in water, sewage, and industrial waste treatment; their application, significance, and control. I, II; 1 to 2 units. DIETZ, ENGELBRECHT.

450. **Hydrology and Flood Control.** Magnitude and frequency of flood flow of streams, minimum flow of streams, and regulation of flow by storage reservoirs; intense rainfall and the development of intensity curves for use in rational run-off formula; unit-graph method of computing flood run-off; flood control and prevention by channel improvement, levees, and reservoirs. I, II; 1 unit. Prerequisite: Civil Engineering 250 and 351, or equivalent. DOLAND.

452. **Water Resources Planning and Development.** Purposes and techniques of planning water resources developments; methods of evaluating the engineering and economic aspects of water conservation projects developed through the examination of actual proposals. II; 1 unit. Prerequisite: Bachelor of Science degree in civil engineering or consent of instructor. DOLAND.

455. **Water Power Engineering.** Preliminary investigations of site, available water supply, machinery selection, design of water passages, arrangement and space allocation in power houses, load curve studies, hydrosteam association, and speed and pressure regulation. II; 1 unit. Prerequisite: Civil Engineering 250 or 450. DOLAND.

457. **Hydraulic Engineering Laboratory.** Design, construction, and testing of individual or semi-individual laboratory projects. Study and discussion of advanced subjects of hydraulic engineering phenomena. I; 1 to 2 units. Prerequisite: Bachelor of Science degree in civil engineering or consent of instructor. GUILLOU.

458. **Open Channel Flow.** Classification of types of flow, channel roughness, backwater curve computations, hydraulic jump analysis, special transitions, canal design, study of supercritical velocity flow, unsteady flow and flood movements; modern developments in open channel flow theory and design practice. II; 1 unit. Prerequisite: Bachelor of Science degree in civil engineering or consent of instructor. CHOW.

460. **Structural Analysis.** Basic theory of indeterminate structures; deflections and displacements; continuous beams and frames; virtual work; qualitative and quantitative influence lines. I, II; 1 unit. Prerequisite: Bachelor of Science degree in engineering with a course in theory of simple structures. OLIVER, VAWTER.

461. **Structural Theory and Design.** General theory of continuity; moment distribution; the column analogy; rigid frame bridges and buildings; fixed and continuous arches; classification of structures from viewpoint of design. I, II; 1 to 2 units. Prerequisite: Bachelor of Science degree in civil engineering with a basic course in indeterminate structures. SHEDD, VAWTER.

462. **Structural Theory and Design.** Statically indeterminate trusses; continuous trusses; steel arches; secondary stresses; suspension bridges; long-span roofs; skeleton steel buildings. I, II; 1 to 2 units. Prerequisite: Bachelor of Science degree in civil engineering with a fundamental course in indeterminate structures. SHEDD, VAWTER.

463. **Analysis and Design of Prestressed Concrete Structures.** The principles of linear prestressing; study of materials used in prestressed concrete; methods

of linear prestressing; design of simple beams on the basis of working stresses and on the basis of the ultimate load; statically indeterminate prestressed concrete structures; design of continuous prestressed concrete beams. I, II; 1 unit. Prerequisite: Bachelor of Science degree in civil or architectural engineering with courses in structures and reinforced concrete design. KHACHATURIAN.

464. **Reinforced Concrete Design.** Theories of action of beams, slabs, and columns of reinforced concrete; codes and specifications and their influence on design; effect of continuity. I, II; 1 unit. Prerequisite: Bachelor of Science degree in engineering wih undergraduate courses in structures. SHEDD.

465. **Steel Design.** Design of steel members; codes and specifications for buildings; riveted and welded connections; evolution of bridge specifications; loads and working stresses; economic proportions. I, II; 1 unit. Prerequisite: Bachelor of Science degree in engineering with courses in structures. SHEDD.

466. **Behavior of Reinforced Concrete Members.** Studies of the actual behavior and strength of reinforced concrete members by means of critical reviews of the more significant experimental and analytical investigations. Emphasis is placed on the empirical nature of current design specifications and their relation to the results of research. Beams subjected to pure flexure, columns subjected to axial compression, combined flexure and axial compression, combined flexure and shear, and bond. I; 1 unit. Prerequisite: Bachelor of Science degree in civil or architectural engineering with courses in structures and reinforced concrete design. SIESS.

467. **Behavior of Reinforced Concrete Structures.** Continuation of Civil Engineering 466. Studies of behavior and strength of statically indeterminate reinforced concrete structures and structural elements: frames, floor slabs in buildings, isolated column footings. II; 1 unit. Prerequisite: Civil Engineering 466 or consent of instructor. SIESS.

469. **Wood Structures.** Theory and practice in the design of modern wood structures; the effect of the plant origin and physical structure of wood on its mechanical strength; fasteners and their significance in design and the development of design formulas. I, II; 1 unit. OLIVER.

470. **Earth Pressures and Retaining Walls.** A study of earth pressures considering the significant properties of soils; methods of computing earth pressures and the limitations in their dependability; stability computations; and the design and construction of retaining walls and abutments. I; 1 unit. Prerequisite: Bachelor of Science degree in civil engineering. YOUNG.

471. **Earth and Masonry Dams.** Stability of rolled-fill and hydraulic-fill earth dams and rock-filled dams; methods of construction; seepage losses; control of seepage forces; safety of foundation. Solid gravity, arched gravity, arch, multiple arch, and slab and buttress dams; safety against sliding and overturning; unit stresses on horizontal sections and principal stresses; joints; drainage; foundations. II; ½ to 1 unit. PECK, YOUNG.

473. **Soil Mechanics.** Advanced studies of research techniques in soil mechanics and foundation engineering. I; 1 unit. Prerequisite: Civil Engineering 374 or consent of instructor. PECK.

474. **Foundation Engineering.** Critical study of case histories of projects in foundation engineering; current procedure for design and construction of

foundations, embankments, and waterfront structures. II; 1 unit. Prerequisite: Credit or registration in Civil Engineering 374 or consent of instructor. Deere, Peck.

475. **Soil Engineering for Transportation Facilities.** Problems of soil classification; factors affecting the stability of subgrades, slopes, and embankments. I; 1 unit. Prerequisite: Civil Engineering 373 or equivalent. Thornburn.

481. **Numerical and Approximate Methods of Structural Analysis.** Methods of successive approximations and numerical procedures for the solution of complex problems with applications to bridges, buildings, and aircraft structures: influence lines, moments and deflections of beams with axial load, buckling strength of columns, moments and deflections of beams resting on elastic or plastic supports, vibration of beams, analysis of arches, moments and deflections of plates, and other problems. I, II; 1 to 2 units. Austin, Chen.

482. **Advanced Numerical Methods in Engineering.** Basic concepts in numerical and approximate methods: successive approximations, relaxation, finite differences, ordinary boundary value problems, initial value problems, partial differential equations, characteristic value problems, methods of interpolation, variational procedures. Special study of selected topics including vibrations of complex structures, blast, impact, and earthquake effects on structures, buckling and flexure of frameworks, torsion of solid and thin-walled sections, lateral buckling of beams, bending and buckling of plates and of stiffened plates, plane stress and axially symmetric problems in elasticity, and other topics. II; 1 to 2 units. Prerequisite: Civil Engineering 481. Austin.

483. **Analysis and Design of Plates and Shells.** Fundamental theories of bending and buckling of plates; practical application of theories in analysis and design of reinforced concrete bridge and building floors, highway and airport pavements, and structural plate components in metal; theory of shells with application to tanks, pressure vessels, shell roofs and hipped plate construction. II; 1 to 2 units. Prerequisite: Consent of instructor. Veletsos.

484. **Behavior of Structures Under Dynamic Loads.** Free vibrations, forced vibration, and transient response of structures and structural components having one or many degrees of freedom; analytical methods for the effects of wind load, explosion blast, impact, earth tremors, and other time dependent excitations; effects of damping and inelastic action; propagation of stress waves; wind induced vibrations with application to cables, pipelines, and tall stacks. I; 1 to 2 units. Prerequisite: Consent of instructor. Veletsos.

485. **Behavior of Steel Structures.** Studies of the behavior of metal structures; significance in terms of design and development of specifications; critical evaluations of experimental investigations of columns, beams, and frames loaded to failure; strength of riveted, bolted, and welded connections; brittle fracture; fatigue; and impact. I or II; 1 unit. Prerequisite: Bachelor of Science degree in civil engineering or consent of instructor. Munse.

486. **Design of Lightweight Structures.** Analysis and design of structures and structural members of minimum weight. I, II; 1 to 2 units. Prerequisite: Bachelor of Science degree with previous work in statically indeterminate structures. Gaylord.

487. **Design of Structures for Dynamic Loads.** Nature of dynamic loading from earthquakes and bomb blasts; nature of dynamic resistance of structural elements and complete structures; concepts of limit design; review of meth-

ods of analysis; significance and interpretation of results of analyses; criteria for design of blast resistant structures; criteria for design of earthquake resistant structures; application to actual problems. II; 1 to 2 units. NEWMARK.

491. **Thesis (M.S.).** I, II; ½ to 2 units.

492. **Thesis (Ph.D.).** I, II; ½ to 4 units.

493. **Special Problems.** Individual investigations or studies of any phase of civil engineering selected by the student and approved by his adviser and the staff member who supervises the work. I, II; ½ to 4 units.

495. **Highway and Traffic Seminar.** Presentation and discussion of current problems and research developments in highway transportation, administration, and engineering. Should be followed by Civil Engineering 496. I; no credit. BAERWALD, DANNER.

496. **Highway and Traffic Seminar.** Continuation of Civil Engineering 495. Presentation and discussion of current problems and research developments in highway transportation, administration, and engineering. II; no credit. BAERWALD, DANNER.

Suggested Topics for Civil Engineering 493

A sufficient number of regular courses have been established to cover adequately some phases of civil engineering. Even in these, students may wish to take advantage of Civil Engineering 493 for special studies. In other phases, extensive use is made of Civil Engineering 493 to cover subjects not now included in the regular courses. The following topics are suggested, but registration is not restricted to these topics.

HIGHWAY AND TRAFFIC ENGINEERING

Highway Transportation. Functions of transportation in the economic system; types of transportation, characteristics and uses of each type; development of highway transportation; elements of highway transportation, their organization and functions; regulation of transportation.

Highway Organization and Administration. Highway agencies and their division of responsibilities; principles of administrative organization; forms of highway administrative bodies and legislative control; analysis of highway agency functions and organizational development; personnel management; public relations.

Highway Economics and Finance. Composition of highway transportation costs; analysis of highway costs and costs of vehicle operation; sources of highway funds, taxation, bonds, toll roads; highway benefits and basis for distribution of highway costs; allocation of funds to highway agencies.

Highway Laws and Regulations. Street, highway, and traffic department legal rights and responsibilities; intergovernmental relations; right-of-way control and freeway laws; traffic laws and ordinances; driver licensing; vehicle inspection; development of uniform laws and ordinances.

Traffic Engineering Operations. Theory of traffic control; laws and ordinances; design and application of traffic control devices; special street designa-

tions; parking design and control; street illumination; miscellaneous traffic control designs.

Traffic Records and Accident Analyses. Types of traffic record systems; design of record forms; annual inventory of traffic safety activities; analysis of traffic accidents, vehicular and pedestrian; engineering factors in accidents; non-engineering records of value to the traffic engineer; coordination of engineering education and enforcement.

Geometric Highway Design. Highway classification; highway capacity; highway design controls; sight distance; horizontal and vertical alignment; cross section elements; highway types; controlled access highways; design of at-grade intersections, grade separations, and interchanges.

History and Development of Highways

Highway Materials

Roadway Location and Design

Highway Planning and Programming

Highway Maintenance and Operation

Analyses of Traffic Problems

HYDRAULIC ENGINEERING

Hydraulics of Surface Drainage. Applications of hydraulics and hydrology; elements of channel design, hydrologic determination of design flow, hydraulics of bridge openings and culverts; hydraulic analysis of overland flow, flow in gutters and inlets, and hydrologic and hydraulic design of bridge opening and a culvert system.

Irrigation

Navigation

Sanitary Aspects of River Control

RAILWAY ENGINEERING

Yards and Terminals

Signaling

Grade Crossing Elimination

Economics of Train Operation

Rail Design and Defects

Track Under Load

Courses for Graduates and Advanced Undergraduates

306. **Photogrammetry.** A study of aerial surveying in civil engineering practice. Characteristics and interpretation of aerial photographs; stereovision; mosaics; economics of photogrammetry; map reproduction. Practice in the preparation of a topographic map from aerial photographs. I; ½ unit. Prerequisite: Civil Engineering 207 (Summer Surveying Camp); senior standing or consent of instructor.

319. **Advanced Surveying.** Advanced problems in topographic engineering; control surveys, special mapping projects, construction surveys, and special surveys. The utilization of maps and survey data in civil engineering practice.

II; ½ unit. Prerequisite: Civil Engineering 207 (Summer Surveying Camp); senior standing or consent of instructor. SCHMIDT.

323. **Highway Traffic Characteristics.** Driver characteristics, vehicle characteristics, and traffic behavior as related to highway design and operation; traffic planning studies, field problems. I; 1 unit. Prerequisite: Civil Engineering 220 or consent of instructor. BAERWALD.

324. **Airport Design.** Specifications and regulations; site selection, soil investigation, layout, drainage, pavement, buildings, hangars, and other engineering features of airport design and construction; management, operation, and maintenance. II; ½ to 1 unit. Prerequisite: Senior standing in civil engineering or consent of instructor. CHRYSSAFOPOULOS.

332. **Engineering Properties of Soils.** Laboratory practice in testing, identification, and classification of soils; study of development of test procedures and basic theories involved; calculations and preparation of graphs using test data. Tests include those for classification, determination of physical properties, and job control. I, II; ½ unit. Prerequisite: Senior standing in engineering or consent of instructor. BAUER.

344. **Water and Sewage Treatment.** Principles, design, and operation of water purification and sewage treatment works; correlation of these aspects with various laboratory control tests, their application, interpretation, and limitations as used in practice. I; 1 unit. DIETZ, ENGELBRECHT.

345. **Public Health Engineering.** The application of engineering principles to the control of environmental sanitation, including disease and immunity, epidemiology, biostatics, industrial hygiene, atmospheric pollution, housing, refuse collection and disposal, milk and food sanitation, and plumbing. II; ½ unit. DIETZ, ENGELBRECHT.

351. **Drainage and Flood Control.** Land drainage, river improvement, flood control. II; ½ unit. Prerequisite: Civil Engineering 250. DOLAND.

355. **Water Power Engineering.** Analysis of hydrologic and power market data; selection of site and hydraulic machinery; preliminary design of water passages and power house; formal reports on projects. II; 1 unit. Prerequisite: Civil Engineering 250. YOUNG.

356. **Hydraulic Engineering Laboratory.** Fundamental principles, operation and use of model laboratories, dimensional analysis, hydraulic similitude, theory and design of hydraulic models. II; ¾ unit. Prerequisite: Theoretical and Applied Mechanics 232 and 234. GUILLOU.

359. **River Hydraulics.** The physiographic function of rivers and streams, stream gaging and analysis, river hydrology, river mechanics, stream sanitation, river navigation, stream control structures. I; ¾ unit. Prerequisite: Theoretical and Applied Mechanics 232. GUILLOU.

361. **Statically Indeterminate Structures.** Elastic theory and its applications to statically indeterminate structures. I, II; ½ unit. Prerequisite: Civil Engineering 262; credit or registration in Civil Engineering 264. BRISCOE, OLIVER.

362. **Statically Indeterminate Structures.** Continuation of Civil Engineering 361. I, II; ½ unit. Prerequisite: Civil Engineering 361, or 262 and consent of instructor. BRISCOE, HALTIWANGER, VAWTER.

370. **Foundations and Retaining Walls.** Evaluation of subsoil conditions as they affect the behavior, proportions, and choice of type of foundations; relations between foundation and other structural problems; design and con-

struction of retaining walls and abutments including the study of earth pressure theories; applicability of analytical methods used to other problems involving natural phenomena. I, II; ¾ to 1 unit. Special problems are required of students who register for one unit. Prerequisite: Civil Engineering 230 and 263. Briscoe, Deere, Ireland.

371. **Earth and Masonry Structures.** Design and construction of gravity masonry dams, earth dams and embankments, rock-fill dams, and the substructure for bridges and buildings. I, II; ½ unit. Prerequisite: Credit or registration in Civil Engineering 264 and 370, or consent of instructor. Daily.

373. **Introduction to Soil Mechanics.** Identification, description, and physical properties of soils; subsurface exploration; engineering characteristics of natural deposits of soil. I; 1 unit. Prerequisite: Graduate standing or credit or registration in Civil Engineering 370. Deere.

374. **Applied Soil Mechanics.** Application of soil mechanics to foundations of buildings; stability of earth slopes; braced cuts and tunnels; damage due to construction operations. II; 1 unit. Prerequisite: Civil Engineering 373. Deere, Peck.

375. **Engineering Aspects of Surficial Soils.** Use of geologic, pedologic, and air-photo information for identification and evaluation of the engineering properties of surficial soils. II; 1 unit. Prerequisite: Civil Engineering 230 or consent of instructor. Thornburn.

Courses in Theoretical and Applied Mechanics

Courses for Graduates

412. **Vibration Analysis.** Continuation of Theoretical and Applied Mechanics 311. Specific topics are systems of several degrees of freedom; applications of generalized coordinates and Lagrange's equations; boundary value problems in vibration of elastic bodies, including strings, rods, and beams; Stodola's method; iteration process and matrix procedure; vibrations in reciprocating machines, airplane structures and propellers; impact and transient vibrations; self-excited vibration; stability; nonlinear systems. II; 1 unit. Prerequisite: Theoretical and Applied Mechanics 311. Jones.

416. **Energy Principles in Engineering Mechanics.** Designed to introduce the student to the variational principles of mechanics and their applications to engineering problems. The derivation, interpretation, and applications of the principle of virtual displacements, the principle of minimum potential energy, the principle of complementary energy, Castigliano's theorem, Hamilton's principle, and Lagrange's equations of motion constitute the main part of the course. Variational methods of approximation are treated briefly. The material includes numerous illustrative applications to stress analysis of statically determinate and statically indeterminate frames, problems of elastic stability, the theories of rings and curved beams, the theory of elastic plates, vibrations of structures, and wave motions. II; 1 unit. Langhaar.

421. **Mechanics of Materials.** Methods of obtaining relations between loads and stresses and strains in various members. The main topics covered in this course and in Theoretical and Applied Mechanics 422 are curved beams, unsymmetrical bending, thick-walled cylinders, beams on elastic supports, contact stresses, torsion of members with non-circular cross-section, stress

concentrations, elastic energy methods applied to statically indeterminate members, flat plates, inelastic behavior of various types of members. Introduction to mathematical theory of elasticity; elastic and plastic buckling; criteria of failure by yielding and by fracture. I; ½ to 1 unit. SIDEBOTTOM, SMITH.

422. Mechanics of Materials. Continuation of Theoretical and Applied Mechanics 421. II; ½ to 1 unit. Prerequisite: Theoretical and Applied Mechanics 421. SIDEBOTTOM, SMITH.

424. Properties of Engineering Materials. Structure of metals and behavior of materials under various conditions of loading and use, including static, creep, fatigue and impact; effects of high and low temperature, strain rate, state of stress, and internal structure; criteria of failure; relation of mechanical properties to behavior; significance of mechanical properties; tests and interpretation of test data; material specifications. II; ½ to 1 unit. COLLINS.

427. Theories of Mechanical Properties and Behavior of Plain Concrete. Theories used in the design of concrete and the factors affecting the properties and behavior of the material and of the test piece. Behavior of plain concrete under different types of environment and of loading, such as long time, repeated, and triaxial, are emphasized. The studies involve critical reviews of experimental and analytical investigations. I; ½ to 1 unit. KESLER.

431. Theory of Ideal Fluid Flow. Together with the following course, topics in advanced fluid mechanics are covered that are the basis of many modern developments. Ideal fluid theory is concerned with an incompressible fluid of negligible viscosity. The differential equations of motion are derived and the several methods of obtaining flow solutions are presented: the obtaining of velocity potentials and stream functions by superposition of the effects of source, doublets, and vortices, and by the methods of conformal mapping. Relations for finding the resultant forces and moments on bodies are derived and applied to bodies such as lifting surfaces. Other topics covered include the theory and application of free streamline flows, vortex motions, and surface wave theory. I; 1 unit. Prerequisite: An elementary course in fluid flow and a course in advanced calculus or equivalent. ROBERTSON.

432. Theory of Flow of Viscous Fluids. Although a logical continuation of Theoretical and Applied Mechanics 431, this course need not be taken sequentially. Concerned with the theoretical development, analysis, and solution of incompressible viscous fluid flow problems. Starting with the stress relations occurring in viscous fluids, the differential equations of motion are derived and direct and approximate solutions for laminar flows are developed. Boundary-layer theory is presented and the occurrence of turbulence and its characterization introduced. The basic equations for analyzing turbulent flows are introduced and approximate solution for flows in boundary-layers with and without pressure gradients (and separation) pipes and jets are presented. Includes consideration of experimental observation and application to technological problems. II; 1 unit. Prerequisite: An elementary course in fluid flow and a course in differential equations or in advanced calculus. ROBERTSON.

451. Theory of Elasticity with Application to Engineering Problems. A study of the mechanics of elastic deformable bodies, based on the fundamental concepts of equilibrium, geometry of strain, and properties of materials. Rela-

tions between stresses, strains, and displacements are studied in detail with special consideration given to their significance in engineering problems. I; 1 unit. LANGHAAR, STIPPES.

452. Theory of Elasticity with Application to Engineering Problems. Continuation of Theoretical and Applied Mechanics 451. II; 1 unit. Prerequisite: Theoretical and Applied Mechanics 451. LANGHAAR, STIPPES.

454. Theory of Shells. A course designed to provide the theoretical basis of stress analysis of shell-type structures, such as ships, submarines, monocoque aircraft structures, concrete roofs and domes, pressure vessels, and containers for liquids. The material includes the differential geometry of shell theory, equilibrium equations, momentless theory of shells, strains in shells, statically indeterminate problems of shells, energy formulations, and stability of shells. II; 1 unit. LANGHAAR.

461. Inelastic Behavior of Engineering Materials (Theory of Plasticity). An outline of a general theory of inelastic behavior involving the relations between loads and stresses and strains in various members that are stressed beyond the elastic range. The cases considered include those in which the inelastic actions involve bodies which are made of materials that behave ideally viscous, ideally plastic, and combinations of the two. Some specific topics are mechanisms of inelastic action of members in which the stresses and strains are essentially uni-axial, such as straight beams, curved beams, and members subjected to combined axial and bending loads; deflection of beams; statically indeterminate members loaded inelastically; inelastic buckling; "shake down" of simple statically indeterminate members; etc. I; ½ to 1 unit. SMITH.

462. Inelastic Behavior of Engineering Materials (Theory of Plasticity). The physical and mathematical formulation of the mechanics of inelastically deformed bodies, plastic stress-strain laws, and their association with yield and loading functions. Deals primarily with members subjected to biaxial and triaxial stress conditions. Specific topics include applications to flexure and torsion of prismatic members; expansion of thick-walled cylinders and spherical shells; introduction to problems in plane plastic flow and variational plasticity. II; ½ to 1 unit. Prerequisite: Theoretical and Applied Mechanics 451 or equivalent. SMITH.

464. Theory of Buckling. The pertinent information and theoretical background required for the prediction of failure by buckling of structures such as airplanes, ships, bridge trusses, fabricated towers and shells; practical illustrations. Specific topics are elastic columns with various end restraints; buckling of frameworks, arches, rings, and plates; inelastic buckling of columns and plates; lateral buckling of beams; energy theory; Ritz procedure; Euler's equation of the calculus of variations. II; ½ to 1 unit. LANGHAAR.

491. Thesis (Master's). I, II; ½ to 2½ units. STAFF.

492. Thesis (Doctor's). I, II; 1 to 4 units. STAFF.

493. Advanced Independent Study (Special Problems). Individual investigation of studies, either analytical or experimental, in one or more phases of theoretical and applied mechanics, including mechanics of materials, theory of elasticity, theory of plasticity, properties of materials, mechanical vibrations, hydraulics and fluid mechanics, fatigue of metals, etc. I, II; ½ to 2 units. STAFF.

Courses for Graduates and Advanced Undergraduates

311. **Mechanical Vibrations.** Kinematics of vibratory motion; comprehensive study of vibrating systems having a single degree of freedom. Specific topics are natural frequencies in undamped vibration and the energy (Rayleigh) method; viscous, Coulomb, and solid (hysteresis) damping; forced vibration; work done by harmonic forces; method of complex algebra; critical speeds and balancing; balancing machines; vibration isolation; vibration instruments. For systems with several degrees of freedom, specific topics are modes; coupled vibrations; vibration absorbers and dampers; vehicle suspension; Holzer's analysis for torsional systems. I, II; ½ to 1 unit. Prerequisite: Theoretical and Applied Mechanics 154 or 156, or 211 and 221. Bowman, Jones.

321. **Advanced Mechanics of Materials.** Methods used in elementary mechanics of materials are expanded and generalized and used to solve more complex problems. Thick-walled cylinders, torsion of bar having non-circular cross-section; curved beams, unsymmetrical bending, flat plates; theories of failure. Use of energy methods for determining deflections and for solving statically indeterminate problems. I, II; ½ to 1 unit. Prerequisite: Theoretical and Applied Mechanics 221 and 223. Sidebottom, Smith.

323. **Advanced Laboratory in Materials Testing.** Calibration of testing machines and of strain measuring instruments. Use of various mechanical and electrical strain gages; determination of the mechanical properties of five different materials under various types of tests: tension, compression, torsion, flexure, impact, and hardness; interpretation of test results. Relation of tests to specifications of materials. I, II; ½ to 1 unit. Prerequisite: Theoretical and Applied Mechanics 221 and 223. Collins, Wetenkamp.

326. **Experimental Stress Analysis.** Measurement of strains or deformations that are of significance in the engineering design of load resisting members. Sysmatic applications of optical, electrical, and physical properties of matter to the instrumentation and measurement of model or prototype stresses. The methods studied include models, analogies, brittle coatings, electrical resistance gages, photoelasticity, etc. I, II; ½ to 1 unit. Prerequisite: Theoretical and Applied Mechanics 150, 211, 221, and 223. Theoretical and Applied Mechanics 321 is desirable. Bowman.

334. **Fluid Mechanics and Advanced Hydraulics.** A study of the basic properties of fluids in general, particularly those that influence the flow of fluids in pipes and open channels, viscosimetry, dimensional analysis, effect of boundary conditions, cavitation, water tunnel, hydraulic jump, water hammer, pumps, turbines. Some laboratory work. II; ½ to 1 unit. Prerequisite: Theoretical and Applied Mechanics 232 and 234. Lansford.

346. **Dimensional Analysis and Theory of Models.** The nature and use of dimensions, systematic calculation of dimensionless products, algebraic theory of dimensional analysis, similarity and model laws, and derivation of model laws from differential equations. Applications include von Karman's theory of similarity in turbulent flow, boundary layer theory, topics in open channel flow, model laws for pumps and turbines, topics in structural analysis and vibration theory, topics in the theory of heat. II; ½ to 1 unit. Langhaar.

Suggested Courses in Other Departments

Courses for Graduates and Advanced Undergraduates

MATHEMATICS

343. **Advanced Calculus.** I, II; 1 unit. Prerequisite: One year of calculus.

345. **Differential Equations and Orthogonal Functions.** I, II; 1 unit. Prerequisite: One year of calculus.

385. **Digital Computer Programming.** I, II; 1 unit. Prerequisite: Senior standing; consent of instructor.

PHYSICS

383. **Atomic and Solid State Physics for Engineers.** This course introduces the student to basic concepts necessary to the understanding of many modern developments in engineering. Topics covered include the basis for the atomic theory of matter; introduction to quantum mechanics; atomic structure; chemical bonds and molecules; theory of the electrical and magnetic properties of solids; imperfections in crystals; semi-conductors; thermionic emission and related topics. I, II; ¾ or 1 unit. SLICHTER.

Suggested Programs for the Master's Degree

From the courses offered in civil engineering and in other departments the student may select a variety of programs of study. He is assisted by his adviser in selecting courses which complete his background of fundamental work and which advance his knowledge in one of the fields of specialization in the department.

The following programs are presented only to help the student to evaluate the possibilities of programs in specific fields. Departures from the suggested programs may be made, in consultation with the adviser, in order to adjust individual programs to the background of the student and to his particular fields of interest. The programs given are for full-time graduate students. Research or teaching assistants normally follow half-time programs and cover the same material as full-time students but at the rate of two and one-half to three units each semester for their two years of study.

Study beyond the degree of Master of Science is an entirely individual matter and each program is carefully reviewed and selected by the student and his adviser.

HIGHWAY ENGINEERING

First Semester		Units
C.E. 420	Highway Pavement Design, I	1
C.E. 475	Soil Engineering for Transportation Facilities	1
C.E. 493	Special Problems	
	Highway Transportation	1
	Highway Economics and Finance	1
C.E. 495	Highway and Traffic Seminar	0
Selected Course		0 to 1
		4 to 5

Second Semester		Units
C.E. 375	Engineering Aspects of Surficial Soils	1
C.E. 421	Highway Pavement Design, II	1
C.E. 493	Special Problems	
	Hydraulics of Surface Drainage	1
	Geometric Highway Design	1
	Highway Organization and Administration	1
C.E. 496	Highway and Traffic Seminar	0
		5

Other Courses. A student may wish to emphasize some special phase of highway engineering such as drainage, soils, surfaces, materials, traffic, or administration. For this reason, he may wish to substitute other courses in the program which more nearly fit his needs. A full program in traffic engineering is outlined under that heading.

HYDRAULIC ENGINEERING

First Semester		Units
C.E. 373	Introduction to Soil Mechanics	1
C.E. 450	Hydrology and Flood Control	1
C.E. 457	Hydraulic Engineering Laboratory	1¼
C.E. 470	Earth Pressures and Retaining Walls	1
		4¼

Second Semester		Units
C.E. 359	River Hydraulics	¾
C.E. 452	Water Resources Planning and Development	1
C.E. 455	Water Power Engineering	1
C.E. 458	Open Channel Flow	1
C.E. 471	Earth and Masonry Dams	1
		4¾

Other Courses. Special problems in hydraulic engineering or courses in other fields related to it may be substituted for some of the subjects suggested above. Special attention is called to the desirability of Theoretical and Applied Mechanics 431, 432, and 433.

RAILWAY ENGINEERING

First Semester		Units
C.E. 373	Introduction to Soil Mechanics	1
C.E. 425	Railroad Location and Operation	1
C.E. 475	Soil Engineering for Transportation Facilities	1
Econ. 484	Economics of Transportation	1
Selected Course		0 to 1
		4 to 5

Second Semester	Units
C.E. 426 Railroad Location and Operation	1
C.E. 493 Special Problems	2
Econ. 485 Economics of Transportation	1
Selected Course	1
	5

Other Courses. In addition to the courses in Special Problems there are a number of graduate courses in the Civil Engineering Department and in other departments of the University which may be included as part of this program.

SANITARY ENGINEERING

First Semester	Units
*Bact. 300 General Microbiology	1
I.E. 333 Engineering Application of Statistics	½ to 1
C.E. 440 Water Supply	1
C.E. 446 Water Purification and General Sanitation	1
C.E. 491 Thesis	½ to 1
	4½ to 5

Second Semester	Units
C.E. 345 Public Health Engineering	½
C.E. 443 Sewerage	1
C.E. 444 Sewage Disposal, Wastes Disposal, and General Sanitation	1
*C.E. 448 Sanitary Engineering Laboratory	1
C.E. 491 Thesis	1
	4½

Other Courses. Any of the following courses, descriptions of which are included in the Graduate College catalog, may be suitable for those marked * above: Bacteriology 300, 308, 326; Chemistry 326, 336, 337, 350, 397, 398; Civil Engineering — any 300 or 400 series course; Health Education 403; Mathematics 341, 342, 345, 369; Political Science 305, 306, 312, 406; Veterinary Pathology and Hygiene 332; Zoology 343.

SOIL MECHANICS

SOIL MECHANICS AND FOUNDATIONS

First Semester	Units
C.E. 332 Engineering Properties of Soils	½
C.E. 373 Introduction to Soil Mechanics	1
C.E. 460 Structural Analysis, or C.E. 461. Structural Theory and Design	1
C.E. 470 Earth Pressures and Retaining Walls	1
Geol. 450 Geology for Civil Engineers	1
	4½

Second Semester	Units
C.E. 374 Applied Soil Mechanics	1
C.E. 375 Engineering Aspects of Surficial Soils	1
C.E. 471 Earth and Masonry Dams	1
C.E. 474 Foundation Engineering	1
C.E. 493 Special Problems	½ to 1
	4½ to 5

First Semester		Units
C.E. 373	Introduction to Soil Mechanics	1
C.E. 461	Structural Theory and Design	1
C.E. 470	Earth Pressures and Retaining Walls	1
Geol. 450	Geology for Civil Engineers	1
Selected Course		0 to 1
		4 to 5

Second Semester		Units
C.E. 374	Applied Soil Mechanics	1
C.E. 462	Structural Theory and Design	1
C.E. 465	Steel Design	1
C.E. 471	Earth and Masonry Dams	1
C.E. 474	Foundation Engineering	1
		5

Other Courses. Special Problems in Soil Mechanics and Structures or other courses in these and related fields may be substituted in the above programs according to the student's previous work and the objectives of his study.

STRUCTURAL ENGINEERING

A wide range of courses is available in this field, leading to specialization in reinforced concrete, steel, theory and analysis, structural dynamics, or other areas. The student selects courses for four to five units of credit each semester, during the two or more semesters of his career, after consultation with his adviser. A well balanced program ordinarily includes four of the five following groups of courses:

1. At least one unit of advanced mathematics (Mathematics 343, 345, or 385 are especially recommended);
2. One or more units of Theoretical and Applied Mechanics (Theoretical and Applied Mechanics 421, 422, 451, 452 are especially recommended);
3. Civil Engineering 461 and additional units in the structural design group (Civil Engineering 462 to 469, 485);
4. Civil Engineering 481 and additional units in analytical or numerical methods (Civil Engineering 482, 483, 484, 486, 487); and
5. At least one unit in soil mechanics and foundation engineering (Civil Engineering 370 to 375, 470 to 475).

The student can fill out his program with other courses in civil engineering, theoretical and applied mechanics, mathematics, or physics (especially Physics 383).

Students who are taking half-time programs of graduate study as research assistants are permitted to take three courses each semester. They will ordinarily take the same type of program as full-time students but will have more time available for elective subjects. However, a research assistant is required to include at least one unit of thesis in his program for the master's degree.

Because of the wide selection of courses specific programs are not suggested here. The student is encouraged to take some courses in other areas than in his specialty to provide a greater depth to his program.

TRAFFIC ENGINEERING

First Semester		Units
C.E. 323	Highway Traffic Characteristics	1
C.E. 420	Highway Pavement Design, I	1
C.E. 493	Special Problems Traffic Engineering Operations	1
C.E. 495	Highway and Traffic Seminar	0
Math. 369	The Ideas and Methods of Statistics	1
Approved Elective		1
		5

Second Semester		Units
C.E. 423	Traffic Planning	1
C.E. 493	Special Problems Geometric Highway Design	1
	Selected Topic	1
C.E. 496	Highway and Traffic Seminar	0
Econ. 384	Economics of Transportation	1
Selected Course		0 to 1
		4 to 5

Other Courses. Work in special problems listed under Civil Engineering 493, Highway and Traffic Engineering, and City Planning 372, Theory and Practice, may be substituted for certain of the courses suggested above.

ENGINEER OFFICERS PROGRAM

The following program is a special graduate program for Army officers in the Corps of Engineers with undergraduate training at the U. S. Military Academy. It is intended to cover a broad range in civil engineering to fit the students for any phase of civil engineering, but there is an opportunity for specialization in one or two areas.

Summer Session		Credits
C.E. 460	Structural Analysis (required course)	1 unit
C.E. 248	Water Supply and Sewerage (not required of men who have had similar training)	4 hours
and/or	Approved Electives, including T.A.M. 421, Advanced Mechanics of Materials, or Math. 345, Differential Equations.	

Four Weeks Following Summer Session		Credits
C.E. 160	Building Construction and Materials	3 hours
C.E. 290	Contracts and Specifications	2 hours

Fall and Spring Semesters

Four to five units each semester including at least one unit from Groups A and B, and two units from Groups C and D in the following lists. The remaining courses should be selected with major emphasis preferably on only two of the

groups of courses listed. However, other courses may be substituted with the approval of the faculty adviser, and other major fields of emphasis may be considered subject to final approval by the Corps of Engineers.

A. Transportation	Units
C.E. 420, 421 Highway Pavement Design	2
C.E. 324 Airport Design	½ to 1
C.E. 425, 426 Railroad Location and Operation	2

B. Hydraulics, Water Supply, and Sewage	Units
C.E. 344 Water and Sewage Treatment	1
C.E. 440 Water Supply	1
C.E. 443 Sewerage	1
C.E. 446 Water Purification and General Sanitation	1
C.E. 450 Hydrology and Flood Control	1
C.E. 452 Water Resources Planning and Development	1
C.E. 455 Water Power Engineering	1
C.E. 458 Open Channel Flow	1
T.A.M. 334 Fluid Mechanics and Advanced Hydraulics	½ to 1

C. Structures	Units
C.E. 461, 462 Structural Theory and Design	1 to 4
C.E. 463 Prestressed Concrete Structures	1
C.E. 464 Reinforced Concrete Design (required course)	1
C.E. 465 Steel Design (required course)	1
C.E. 466, 467 Behavior of Reinforced Concrete Members and Structures	2
C.E. 469 Wood Structures	1
C.E. 481, 482 Numerical and Approximate Methods of Structural Analysis	1 to 4

D. Soil Mechanics and Foundations	Units
C.E. 370 Foundations and Retaining Walls	¾ to 1
C.E. 371 Earth and Masonry Structures	½
C.E. 373 Introduction to Soil Mechanics	1
C.E. 374 Applied Soil Mechanics	1
C.E. 470 Earth Pressures and Retaining Walls	1
C.E. 471 Earth and Masonry Dams	½ to 1
C.E. 474 Foundation Engineering	1
Geol. 450 Geology for Civil Engineers	1

SPECIAL MILITARY PROGRAMS

A number of special programs for officers in the Air Force, Navy Civil Engineers Corps, and Army Corps of Engineers are available. These are based on the general program for engineer officers as outlined above, but provide for greater specialization in such fields as structural dynamics, advanced structural theory, engineering physics, and nuclear engineering. Detailed suggestions and course outlines may be obtained from the head of the department. In general, these programs require the equivalent of two years of study, or at least three semesters and one (or preferably two) summer sessions.

UNIVERSITY OFFICES

Office of Admissions and Records
100a Administration Building
Urbana, Illinois

Graduate College
109 Administration Building (East)
Urbana, Illinois

Department of Civil Engineering
205 Civil Engineering Building
Urbana, Illinois

Housing Division
108 Illini Hall
Champaign, Illinois

Foreign Students' Adviser
152 Administration Building (West)
Urbana, Illinois